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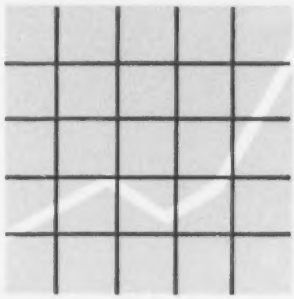

Colorado Business Review

BUSINESS RESEARCH DIVISION • GRADUATE SCHOOL OF BUSINESS ADMINISTRATION • UNIVERSITY OF COLORADO

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Volume LVI, Number 1, January 1983

Review of Economic Policy and Outlook

Aivars Krasts

INTRODUCTION

A friend of mine given to picking up cliches informed me that the world is made up of three types of people: those who make things happen, those who observe things happen, and those who wonder what happened. The "movers and shakers" of a new administration launched their Program of Economic Recovery in 1981 which, with much fanfare in the public media, promised simultaneously and in short order to restart steady economic growth while drastically reducing inflation. Those of us in the observer category have noticed that instead of the promised benefits, high unemployment, high interest rates, mounting federal deficits, and declining industrial production have characterized our economic performance. These observations have, in turn, reduced nearly all of us to wondering what went wrong, what will happen next, can we do anything to fix things, and what can realistically be expected if the proper "fix" is applied. I will cover each of these questions in turn.

WHAT WENT WRONG

The Program for Economic Recovery emphasized four ingredients: reduced taxation, controlled growth in the money supply, reduced growth in non-defense federal expenditures, and increased defense expenditures. It was advertised that the federal budget could be controlled in such a way that funds saved from non-defense outlays would be transferred to defense, and that budget deficits would be eliminated as the tax cuts stimulated economic growth, providing rising government revenue even at lower tax rates. Inflation would be controlled by a tight monetary policy.

As a theoretical framework, this policy mix is not poorly conceived. It points us in the correct direction. The problem with it has been that it required three prerequisites to work expeditiously: (1) the ability to bring the non-defense federal budget with all its indexed entitlement programs under immediate control, (2) an economy that was not already corroded by over a decade of inflation, and (3) an economy capable of instantaneous response to the fiscal stimulus of the tax reductions. These prerequisites simply were not present when the policy was applied.

The Budget Has Not Yet Been Controlled

The federal non-defense budget has proven to be extremely hard to control. The significant part of the growth in federal outlays is accounted for by indexed transfer payments to individuals under a myriad of entitlement programs including Social Security and government pension funds. These were immediately defended by their constituents, and the Administration and Congress quickly backed away from reducing most of these programs because of the political risks involved. By doing so, they eliminated the possibility of bringing federal outlays under control expeditiously.

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Disinflation Is Painful

The architects of the President's program assumed that tax relief measures would more than offset the burden of high real interest rates associated with the Federal Reserve's new strategy of tight money. Consequently, they believed that disinflation could be a relatively painless process. Experience has shown, however, that reducing inflation is an extremely complex and painful process, perhaps analogous to kicking a drug habit.

Although curtailed inflation was almost universally desired, the actual slow-down has, in fact, been a shock to many. When inflation recedes, there are winners and losers. Many of the present losers were accustomed to being winners under previously rapid inflation.

The biggest winner from inflation was the federal government—and on two fronts. The most obvious source of gain was income tax bracket creep. As a result of the progressive personal income tax, a 1% increase in all personal incomes results in a 1.6% increase in personal tax revenues. Consequently, the federal government receives an ever-greater percentage of individuals' real purchasing power when it follows policies that lead to inflation.

In addition, high inflation allows debt to be repaid with substantially cheaper dollars, and the federal government is America's largest debtor. Moreover, the assumed permanence of inflation also led many private companies and individuals in our economy, and foreign governments as well, to overborrow.

This over extension of credit has greatly increased the risk of bankruptcy for both lenders and borrowers. And this is the key reason why the economy today cannot sustain healthy growth. Banks have too many bad loans on their books and businesses must use too much of their cash flow for debt servicing. The economy has, in fact, been badly corroded by previous inflation. With declining inflation, cash flow in nominal dollars is not rising at previously anticipated rates and the debt associated with previous investments has become increasingly burdensome. The bankruptcy rate is currently the highest it has been since the depression. Any benefits obtained from tax reductions have had to be used foremost to strengthen the financial condition of our private companies, rather than for investment in new plant and equipment to generate growth.

What this adds up to is that a sound policy was applied too late to work promptly. The patient was already too weakened by previous neglect to respond quickly to the vitamin shot. But the treatment is appropriate.

Supply Side Economics Has Not Been Tried

A second limitation on the tax cut as a stimulant is that it was simply not big enough. Despite the $750 billion so-called reduction in taxes over five years enacted last summer, the federal government's real tax bite will remain at about 19% of GNP through the 1980s. The tax

cuts only offset the tax increases that would have resulted from continued bracket creep and insufficient depreciation of business investment. They temporarily halted the erosion of the private producing sector's position in the economy and the associated *escalation* of *dis*incentives to work, save, and invest created by inflation. They did not increase the real incentives for productive investment.

Given these limitations, the tax cut was greatly oversold by the Administration, creating unrealistic expectations regarding the size of its benefits and the speed with which they would show up in the GNP growth rate. The concept that lowering tax rates can increase government revenue needs time to be tested. Success depends on dismantling much of the underground economy and tax shelters built up in response to inflation and high marginal taxes. This is a slow process which requires convincing the public that the government will maintain the low tax structure. Only then will citizens respond in productive ways. This would take at least the better half of a decade.

Because it was presented as something that could work immediately, a year later "supply side economics" was pronounced a failure by its opponents and largely derailed by the Tax Equity and Fiscal Responsibility Act of 1982, before it was given a chance to work. As handled in the public arena, "supply side economics" was never more than a "red herring"–the kind of political deception that all too often has been part of our political process.

Monetary Policy Has Limitations

The Federal Reserve was cast in the role of inflation fighter with control of the money supply as its chief weapon. This represents a drastic change in emphasis of its mission of the past two decades, when its central thrust was to accommodate federal budget deficits at a time when the prevailing economic policy was to borrow against future economic growth to pay for sustaining current consumption.

This change in objectives is appropriate, but again its effectiveness is limited by the financially weakened state of borrowers and lending institutions. If the Federal Reserve were to limit the growth of money supply to a level necessary to continue reducing the inflation rate, more business and financial institutions would be threatened with bankruptcy. As the kingpin of the industrialized world's financial system, the Federal Reserve has the primary obligation of preserving that system. When the system is weak, this obligation supercedes its mission to fight domestic inflation. I believe that the easing in credit is an effort to support the system. It is a required adjustment, because we must not bring down our financial system in the effort to eradicate inflation.

In summary, the perspective for projecting the near-term outlook is that of a structurally weakened economy being guided by imperfectly tailored policies, but ones that in most important respects are directionally correct. They need adjustment, not reversal.

THE NEAR-TERM OUTLOOK

Economic statistics suggest that we are on the verge of a business cycle recovery. No sector of the economy shows the potential for exceptional strength. Of particular concern is the weak outlook for business investment. Companies are trying to strengthen their financial condition at the expense of expansion. In many instances this is necessary for their survival. During the past six months, the decline in capital spending seems to have become widespread, and promises to offset most of the stimulus to consumer demand provided by the July 1 tax cut. A

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dollar of investment spending generates more than a dollar of total spending, and unfortunately this multiplier also works in reverse.

Given the factors inhibiting a robust recovery, real economic growth in 1983 is likely to be less than 3%, a lackluster performance coming out of a recession. Unemployment will not decline much even with an economic upturn. A substantial portion of this country's unemployment rate is not just cyclical. Workers who have been displaced by the decline in the capital intensive manufacturing industries will find it extremely difficult to secure jobs in the growing services and high technology sectors. Consequently, the unemployment rate will probably not fall below 9% in 1983.

As a result of underutilized industrial capacity, the present single digit inflation appears sustainable. A rate around 6% in 1983, as measured by the GNP price deflator, is a reasonable forecast. However, the perceived risk of a return to inflationary policies will still remain. Consequently, real long-term interest rates will be greater than the historical 3%, damaging prospects for renewed business investment. The resulting nominal interest rates will be in the low double digits.

NEEDED CHANGES

The picture I have painted is a relatively somber one. However, there are reasons to be cautiously optimistic that changes in attitudes are taking place that could help return the economy to a more solid foundation.

The economy-wide stagnation that we are experiencing has influenced public policy debate in Washington. The folly of borrowing against future economic growth is becoming increasingly understood. Both parties now recognize that perennial budget deficits are counterproductive to prosperous long-term economic performance.

Likewise, the business sector is more carefully scrutinizing long-term obligations. Contracts with labor increasingly recognize that automatic protection against economic downswings and inflation is no longer financially feasible. Moreover, investment opportunities are being evaluated with increased attention to *real* returns, rather than *nominal dollar* returns. As a result of these two factors, the institutional inertia behind spiraling inflation is softening.

Given the deep-rooted problems faced by the Administration, these changes in assumptions used by public and private decisionmakers are encouraging. However, the Administration needs to alter its policies to encourage further progress. A shift from the present policy of tight money combined with loose spending, to easier money and tight budget policy is urgently needed to lower interest rates and improve prospects for business investment. Let's focus on monetary policy.

Needed Adjustment In Monetary Policy

The Federal Reserve must strike a balance between two objectives: preserving the real value of the currency and avoiding a collapse of the financial system. When bankruptcies start to mushroom as a result of a concerted effort to reduce inflation, the Federal Reserve needs to pay greater attention to protecting the integrity of the financial system. As I said earlier, I think that the Federal Reserve is doing so now. The Federal Reserve should continue its more stimulative approach, keeping money supply growth at the top of its target range for the time being, focusing its efforts toward *containing* rather than *reducing* inflation.

Needed Adjustments in Federal Budget Policy

Sound monetary policy alone is not enough to get our economy rolling again. We need a sincere and rigorous effort to pare back government spending. Two areas that warrant close examination are the entitlement or social programs and defense. The automatic cost-of-living provisions in social programs–which make up about 30% of the federal budget–institutionalize and exaggerate the effect of inflation on government spending. The recipients of entitlement programs must be prepared to share in the cost of inflation rather than reap disproportionate benefits from it.

Social Security is the largest of these programs–comprising 25% of the total federal budget. As a result of overindexation, real social security benefits per new recipient climbed by over 50% in the past decade. However, real earnings per employee went up very little. Correcting this disparity would significantly reduce the upward pressure on federal outlays.

In the area of defense, a careful reassessment and setting of priorities is essential. It is simply not politically feasible in peacetime to achieve a meaningful curtailment of entitlement programs, while supporting broad-based expansion of defense outlays. A way must be found to reduce defense outlays without sacrificing legitimate national security needs.

A portion of the resources freed through reductions in defense spending could be directed toward repairing America's infrastructure, such as roads, bridges, and ports. The erosion in our infrastructure over the last decade reflects too little attention to legitimate public responsibilities and has certainly not helped our quest for improved efficiency and competitiveness in world markets. It may turn out that this public investment is necessary to sustain consumer demand at levels that lead to renewed interest in expanding capital investment. Workers displaced by the decline in older industries could be employed to rebuild our decaying public infrastructure. This form of government spending also has the added advantage of being legitimately financed with bonds, because the facilities can raise toll revenue to pay off the debt.

CONCLUSION

If monetary and fiscal policies are brought into closer harmony as I've suggested, real long-term interest rates will gradually decline. Consequently, growth in capital investment should improve. Such a course for capital formation would imply a steady sustainable improvement in real economic growth compared with recent experience. It does not, however, imply a return to the robust growth rates of the 1960s and 1970s of 3.5 to 4.0%. An average real GNP growth rate between 2 and 3% for the latter half of the decade would be a success.

America went on a binge of excessive monetary and fiscal stimulation for almost 15 years, during which time we consumed more than we could produce. Throughout the 1980s, the economy will be working off those excesses in the form of restrained growth. Prudent adjustments in President Reagan's Recovery Program are necessary to reduce the size of the tab, but return to the pre-Reagan policies is not feasible. I know of no better alternatives.

COLORADO BUSINESS INDICATORS
(Figures in Thousands Unless Otherwise Indicated)

	September 1982	August 1982	September 1981	Percent Change September 1982 from August 1982	Percent Change September 1982 from September 1981
Total Civilian Labor Force (by place of residence)[a]	1,521.7	1,523.7	1,500.8	- 0.1	1.4
Unemployment	71.0	69.5	49.0	2.2	44.9
Unemployment Rate (percent)	4.7	4.6	3.3	—	—
Employment	1,450.7	1,454.2	1,451.8	- 0.2	- 0.1
Nonagricultural Wage and Salary	1,281.6	1,282.7	1,291.9	- 0.1	- 0.8
Agricultural	47.8	47.8	48.5	0.0	- 1.4
Self-employed, unpaid family, and domestics	121.3	123.7	111.4	- 1.9	8.9
Total Nonagricultural Wage and Salary Employment (by place of work)[a]	1,279.6	1,279.9	1,290.2	- 0.0	- 0.8
Mining	40.3	41.0	44.1	- 1.7	- 8.6
Metallic Minerals	8.8	8.9	11.6	- 1.1	-24.1
Bituminous Coal, Lignite, and Nonmetallic	4.9	4.9	6.1	0.0	-19.7
Oil and Gas Extraction	26.6	27.2	26.4	- 2.2	0.8
Contract Construction	77.3	78.4	77.4	- 1.4	- 0.1
Manufacturing	175.6	178.2	187.2	- 1.5	- 6.2
Lumber, Wood Products, and Furniture	6.4	6.4	7.3	0.0	-12.3
Stone, Clay, Glass, and Concrete Products	9.6	9.9	11.0	- 3.0	-12.7
Primary and Fabricated Metals	14.6	15.3	19.6	- 4.6	-25.5
Machinery, Except Electrical	26.3	26.6	26.5	- 1.1	- 0.8
Electric and Electronic Equipment	15.3	15.3	16.3	0.0	- 6.1
Transportation Equipment	14.1	14.1	14.4	0.0	- 2.1
Other Durable Goods	26.9	27.2	27.9	- 1.1	- 3.6
Food and Kindred Products	23.1	23.9	23.5	- 3.3	- 1.7
Textiles and Apparel	3.1	3.1	3.3	0.0	- 6.1
Paper and Allied Products	2.0	2.0	2.1	0.0	- 4.8
Printing and Publishing	17.9	17.9	17.6	0.0	1.7
Chemicals and Allied Products	7.6	7.5	7.0	1.3	8.6
Other Nondurable Goods	8.7	8.8	10.5	- 1.1	-17.1
Finance, Insurance, and Real Estate	82.5	82.7	79.9	- 0.2	3.3
Banking	20.8	21.0	20.7	- 1.0	0.5
Credit Agencies Other than Banks	12.8	12.9	12.6	- 0.8	1.6
Insurance Carriers, Agents, and Brokers	20.7	20.6	19.6	0.5	5.6
Real Estate and Combination Offices	20.6	20.7	20.6	- 0.5	0.0
Other Finance, Insurance, and Real Estate	7.5	7.4	6.4	1.4	17.2
Transportation and Public Utilities	80.6	80.8	82.5	- 0.2	- 2.3
Railroad Transportation	6.7	6.5	7.7	3.1	-13.0
Trucking and Warehousing	16.2	16.2	17.4	0.0	- 6.9
Air Transportation	13.1	13.1	14.3	0.0	- 8.4
Other Transportation	6.8	6.8	6.7	0.0	1.5
Communications, Electric, Gas, and Sanitary Services	37.8	38.2	36.5	- 1.0	3.6
Trade	317.1	316.7	314.6	0.1	0.8
Wholesale Trade	78.3	78.5	78.1	- 0.3	0.3
Retail Trade	238.9	238.2	236.5	0.3	1.0
Services	272.6	278.0	265.5	- 1.9	2.7
Lodging and Combination Lodging/Eating Places	24.8	26.6	24.3	- 6.8	2.1
Personal Services	14.1	14.1	13.3	0.0	6.0
Business Services	50.6	50.7	51.3	- 0.2	- 1.4
Auto and Miscellaneous Repair Services	13.7	13.8	13.5	- 0.7	1.5
Amusements and Recreation	16.7	18.9	14.2	-11.6	17.6
Health Services	72.2	72.1	69.3	0.1	4.2
Educational Services	8.6	8.5	8.4	1.2	2.4
Membership Organizations	20.2	20.6	20.0	- 1.9	1.0
Other Services	51.9	52.7	51.3	- 1.5	1.2
Government	233.5	224.2	239.0	4.1	- 2.3
Federal	50.7	51.3	51.0	- 1.2	- 0.6
State	54.4	48.9	56.2	11.2	- 3.2
Local	128.3	124.0	131.7	3.5	- 2.6

	September 1982	August 1982	September 1981	Percent Change September 1982 from August 1982	Percent Change September 1982 from September 1981
Average Weekly Hours					
Construction	36.1	38.3	36.3	- 5.7	- 0.6
Manufacturing	39.4	39.5	39.8	- 0.3	- 1.0
Nondurable Goods	39.3	38.8	38.5	1.3	2.1
Durable Goods	39.6	39.9	40.5	- 0.8	- 2.2
Average Weekly Earnings ($)					
Construction	480.13	505.56	433.42	- 5.0	10.8
Manufacturing	339.23	337.33	331.93	0.6	2.2
Nondurable Goods	324.62	318.94	304.15	1.8	6.7
Durable Goods	350.06	349.12	348.30	0.3	0.5
Initial Unemployment Claims (000)	20.8	17.5	11.3	18.9	84.1
Bankruptcies, All Types (number)	566	506	489	11.9	15.7
Total State Revenue ($000)	494,502	318,081	421,821	55.5	17.2
Total State Expenditures ($000)	501,076	336,153	350,973	49.1	42.8
Crude Oil Production (thous. bbls.)	2,426	2,601	2,464r	- 6.7	- 1.5
Dry Gas Production (mil. cu. ft.)	11,394	12,571	11,113r	- 9.4	2.5
Coal Production	1,290.2	1,487.3	1,771.3	-13.3	-27.2
New Oil and Gas Wells (number)	171	160	201	6.9	-14.9
Natural Gas Used (bil. cu. ft.)	8.4	7.9	8.7	6.3	- 3.4
Electrical Power Sales (mil. kwh)					
Residential	472.6*	481.6	450.1	- 1.9	5.0
Nonresidential	1,157.8*	1,236.4	1,136.9	- 6.4	1.8
Residential permits (number)	1,821	1,629	1,590	11.8	14.5
Residential value ($000)	118,022	116,698	113,272	1.1	4.2
Nonresidential permits (number)	165	171	249	- 3.5	-33.7
Nonresidential value ($000)	43,073	42,300	172,717	1.8	-75.1
Highway Contractor Payments ($000)	18,005	12,211	14,681	47.4	22.6
Ordinary Life Insurance Sales ($000)	842,178	807,563	690,724	4.3	21.9
Savings and Loan Net New Savings ($000)[b]	- 50,100	34,900	- 8,000	—	—
National Park Visits—9 Areas (000)	735.9	1,209.4	807.2	-39.2	- 8.8
Motor Vehicle Title Applications (000)	83.8	85.6	87.4	- 2.1	- 4.1
Highway Vehicle Traffic Counts at Border Stations (daily average)	41,736*	53,008*	43,186	-21.3	- 3.4
Air Passengers, Stapleton (000)[c]	1,920	2,490	1,846	-22.9	4.0
Air Freight and Air Express, Stapleton (thous. lbs.)	27,319	26,541	28,463	2.9	- 4.0
Prices Received by Farmers ($)					
Beef Cattle (per cwt)	59.90	63.30	63.20	- 5.4	- 5.2
Lambs (per cwt)	53.90	54.40	50.60	- 0.9	6.5
Wheat (per bu.)	3.23	3.14	3.54	2.9	- 8.8
Corn (per bu.)	2.19	2.37	3.12	- 7.6	-29.8
Potatoes (per cwt)	4.75	—	5.80r	—	-18.1
Wool (per lb.)	.77	.78	.83r	- 1.3	- 7.2

NOTES: An asterisk (*) indicates preliminary data subject to revision.
Revised data are marked (r).
n.r.—not reported.

[a]Employment figures have been updated to a March 1981 benchmark and are arranged by 1972 Standard Industrial Classifications (SIC). Previously reported data were on a March 1980 benchmark. Thus, these data are not comparable to that published prior.

[b]New series, thus figures are not comparable to those previously published.

[c]Includes scheduled airlines, commuter airlines, and charter passengers.

Employment, Hours, and Earnings data from Colorado Department of Labor and Employment.
Bankruptcies from the Office of the Federal Referee in Bankruptcy.
State Revenue and Expenditures from the State Controller's Office.
Crude Oil Production, Dry Gas Production and New Oil and Gas Wells from the Oil and Gas Conservation Commission.
Coal Production from Colorado State Coal Mine Inspection Department.
Natural Gas Used from Colorado Interstate Gas Company.
Electrical Power Sales from individual companies.
New Construction from Bureau of the Census, U.S. Department of Commerce.
Highway Contractor Payments from the Colorado Highway Department.
Life Insurance Sales from the Life Insurance Marketing and Research Association, Inc.
Savings and Loan Net New Savings from Federal Home Loan Bank of Topeka.
National Park Visits from National Park Service, Denver.
Highway Traffic counts from Colorado Highway Department.
Air Passengers, Freight, and Express from Stapleton International Airport Business Office.
Prices Received by Farmers from U.S. Department of Agriculture.

LOCAL BUSINESS CONDITIONS
(All Figures in Thousands)

	September 1982	August 1982	September 1981
ALAMOSA (1980 pop. 6,830)			
Electric Power (kwh)	3,182	3,067	2,878
Constr. ($)—Res.	91	50	118
—Nonres.	13	17	0
Deposits ($) (2 of 2 banks)	48,943	47,934	46,528
ARVADA (1980 pop. 84,576)			
Electric Power (kwh)	28,491	27,660	28,478
Constr. ($)—Res.	2,528	426	1,046
—Nonres.	1,085	0	395
Deposits ($) (4 of 5 banks)	89,174	90,281	82,379
ASPEN (1980 pop. 3,678)			
Electric Power (kwh)	2,548	3,140	3,462
Constr. ($)—Res.	210	0	288
—Nonres.	0	0	603
Deposits ($) (2 of 3 banks)	74,497	73,740	75,645
AURORA (1980 pop. 158,588)			
Electric Power (kwh)	79,130	79,884	78,780
Constr. ($)—Res.	11,979	9,130	9,384
—Nonres.	170	6,874	4,221
Deposits ($) (7 of 11 banks)	182,424	183,029	161,975
BOULDER (1980 pop. 76,685)			
Electric Power (kwh)	55,941	56,416	47,485
Constr. ($)—Res.	311	2,481	1,159
—Nonres.	1,418	1,302	1,000
Deposits ($) (8 of 8 banks)	451,139	458,221	425,635
BRIGHTON (1980 pop. 12,773)			
Electric Power (kwh)	4,965	5,172	4,733
Constr. ($)—Res.	n.r.	59	493
—Nonres.	n.r.	50	37
Deposits ($) (2 of 2 banks)	53,857	54,137	53,444
BROOMFIELD (1980 pop. 20,730)			
Electric Power (kwh)	10,750	11,176	6,646
Constr. ($)—Res.	185	175	231
—Nonres.	0	566	1,500
Deposits ($) (2 of 2 banks)	50,225	49,800	44,009
CANON CITY (1980 pop. 13,037)			
Electric Power (kwh)	26,327	21,234	24,080
Constr. ($)—Res.	35	148	250
—Nonres.	0	0	0
Deposits ($) (3 of 3 banks)	101,398	102,978	93,081
COLORADO SPRINGS (1980 pop. 215,150)			
Electric Power (kwh)	156,381	162,261	151,353
Constr. ($)—Res.[a]	16,300	9,314	11,290
—Nonres.	5,368	7,511	10,328
Deposits ($) (15 of 19 banks)	876,999	896,174	828,354
COMMERCE CITY (1980 pop. 16,234)			
Electric Power (kwh)	16,299	25,249	25,439
Constr. ($)—Res.	210	104	214
—Nonres.	0	532	790
Deposits ($) (1 of 1 bank)	27,866	35,193	24,892
CORTEZ (1980 pop. 7,095)			
Electric Power (kwh)	2,570	3,383	3,553
Constr. ($)—Res.	123	323	60
—Nonres.	0	23	43
Deposits ($) (3 of 3 banks)	78,941	80,220	71,986
CRAIG (1980 pop. 8,133)			
Electric Power (kwh)	3,716	3,499	4,941
Constr. ($)—Res.	0	81	0
—Nonres.	0	262	0
Deposits ($) (2 of 2 banks)	68,919	70,104	71,975

	September 1982	August 1982	September 1981
DENVER (1980 pop. 491,396)			
Electric Power (kwh)	357,277	356,331	337,589
Constr. ($)—Res.	6,599	8,886	13,356
—Nonres.	8,843	5,514	105,875
Deposits ($) (34 of 38 banks)	6,439,464	6,538,446	5,824,403
DURANGO (1980 pop. 11,426)			
Electric Power (kwh)	5,914	6,589	5,287
Constr. ($)—Res.	0	85	32
—Nonres.	0	90	498
Deposits ($) (3 of 3 banks)	120,399	119,057	108,471
ENGLEWOOD (1980 pop. 30,021)			
Electric Power (kwh)	21,918	21,809	19,872
Constr. ($)—Res.	0	159	5
—Nonres.	1,788	706	466
Deposits ($) (6 of 9 banks)	339,372	344,734	319,881
ESTES PARK (1980 pop. 2,703)			
Electric Power (kwh)	4,450	4,717	4,618
Constr. ($)—Res.	56	0	104
—Nonres.	0	14	88
Deposits ($) (2 of 2 banks)	40,469	40,422	35,153
FORT COLLINS (1980 pop. 64,632)			
Electric Power (kwh)	39,028	44,200	37,386
Constr. ($)—Res.	1,699	2,325	521
—Nonres.	834	1,270	0
Deposits ($) (8 of 8 banks)	366,394	371,503	353,228
FORT MORGAN (1980 pop. 8,768)			
Electric Power (kwh)	7,822	7,697	6,734
Constr. ($)—Res.	50	52	26
—Nonres.	37	0	40
Deposits ($) (2 of 2 banks)	87,346	92,209	81,289
GLENWOOD SPRINGS (1980 pop. 4,637)			
Electric Power (kwh)	4,846	5,404	4,130
Constr. ($)—Res.	n.r.	n.r.	243
—Nonres.	n.r.	n.r.	0
Deposits ($) (3 of 3 banks)	116,037	119,216	111,782
GOLDEN (1980 pop. 12,237)			
Electric Power (kwh)	5,793	6,249	6,055
Constr. ($)—Res.	382	411	0
—Nonres.	0	0	366
Deposits ($) (3 of 3 banks)	127,280	135,931	120,321
GRAND JUNCTION (1980 pop. 28,144)			
Electric Power (kwh)	21,313	21,527	20,012
Constr. ($)—Res.	1,263	4,162	1,449
—Nonres.	10,221	545	1,427
Deposits ($) (5 of 5 banks)	348,880	353,782	338,010
GREELEY (1980 pop. 53,006)			
Electric Power (kwh)	26,678	28,164	23,425
Constr. ($)—Res.	508	228	825
—Nonres.	24	1,657	2,722
Deposits ($) (9 of 9 banks)	413,340	413,461	419,430
GUNNISON (1980 pop. 5,785)			
Electric Power (kwh)	3,298	3,039	2,935
Constr. ($)—Res.	n.r.	0	0
—Nonres.	n.r.	36	0
Deposits ($) (2 of 2 banks)	46,918	46,122	43,555
LA JUNTA (1980 pop. 8,338)			
Electric Power (kwh)	5,044	5,567	4,644
Constr. ($)—Res.	97	53	64
—Nonres.	0	50	105
Deposits ($) (2 of 2 banks)	47,964	46,540	45,009

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LOCAL BUSINESS CONDITIONS—Continued

	September 1982	August 1982	September 1981
LAFAYETTE (1980 pop. 8,985)			
Electric Power (kwh)	2,575	2,369	2,220
Constr. ($)—Res.	1,553	533	222
—Nonres.	775	0	0
Deposits ($) (1 of 1 bank)	16,024	17,027	14,484
LAKEWOOD (1980 pop. 112,848)			
Electric Power (kwh)	60,169	59,260	55,058
Constr. ($)—Res.	4,645	13,209	6,724
—Nonres.	1,061	0	18,213
Deposits ($) (9 of 9 banks)	476,553	485,952	431,395
LAMAR (1980 pop. 7,713)			
Electric Power (kwh)	8,240	7,986	6,976
Constr. ($)—Res.	297	67	0
—Nonres.	0	6	36
Deposits ($) (2 of 2 banks)	72,089	70,902	57,078
LITTLETON (1980 pop. 28,631)			
Electric Power (kwh)	16,342	14,297	17,383
Constr. ($)—Res.	2,518	1,337	1,820
—Nonres.	172	817	3,000
Deposits ($) (7 of 7 banks)	185,301	191,205	161,022
LONGMONT (1980 pop. 42,942)			
Electric Power (kwh)	20,684	20,997	19,363
Constr. ($)—Res.	554	648	413
—Nonres.	0	0	110
Deposits ($) (5 of 5 banks)	177,934	181,784	162,587
LOUISVILLE (1980 pop. 5,593)			
Electric Power (kwh)	17,643[c]	8,474	1,708
Constr. ($)—Res.	2,753	2,868	184
—Nonres.	567	338	106
Deposits ($) (2 of 2 banks)	18,544	18,714	14,291
LOVELAND (1980 pop. 30,244)			
Electric Power (kwh)	17,598	17,598	19,445
Constr. ($)—Res.	1,992	572	128
—Nonres.	0	11	65
Deposits ($) (4 of 4 banks)	131,052	133,484	115,719
MONTROSE (1980 pop. 8,772)[b]			
Constr. ($)—Res.	36	28	337
—Nonres.	56	435	3,244
Deposits ($) (3 of 3 banks)	101,655	103,680	95,139
NORTHGLENN (1980 pop. 29,847)			
Electric Power (kwh)	12,208	12,343	11,097
Constr. ($)—Res.	n.r.	676	568
—Nonres.	n.r.	170	8
Deposits ($) (2 of 3 banks)	57,670	59,010	53,848
PUEBLO (1980 pop. 101,686)			
Electric Power (kwh)	52,102	51,510	51,160
Constr. ($)—Res.	183	439	832
—Nonres.	323	113	115
Deposits ($) (8 of 9 banks)	359,692	356,358	335,051
ROCKY FORD (1980 pop. 4,804)			
Electric Power (kwh)	6,119	6,686	5,771
Constr. ($)—Res.	0	0	0
—Nonres.	0	0	0
Deposits ($) (1 of 2 banks)	13,334	13,483	18,936
SALIDA (1980 pop. 4,870)			
Electric Power (kwh)	1,466	1,359	1,598
Constr. ($)—Res.	0	0	0
—Nonres.	0	0	52
Deposits ($) (2 of 2 banks)	44,100	41,183	39,279
STERLING (1980 pop. 11,385)			
Electric Power (kwh)	6,865	6,022	6,223
Constr. ($)—Res.	45	47	100
—Nonres.	87	0	0
Deposits ($) (3 of 3 banks)	134,303	136,277	123,846
THORNTON (1980 pop. 40,343)			
Electric Power (kwh)	17,227	16,316	15,784
Constr. ($)—Res.	1,158	1,734	1,220
—Nonres.	0	0	2,021
Deposits ($) (1 of 1 bank)	24,017	24,691	20,540
TRINIDAD (1980 pop. 9,663)			
Electric Power (kwh)	3,001	2,800	2,911
Constr. ($)—Res.	183	1,276	62
—Nonres.	323	0	0
Deposits ($) (2 of 2 banks)	52,711	52,075	50,999
WESTMINSTER (1980 pop. 50,211)			
Electric Power (kwh)	25,536	18,839	20,581
Constr. ($)—Res.	4,531	3,725	1,411
—Nonres.	300	160	0
Deposits ($) (2 of 2 banks)	86,407	84,519	81,801
WHEAT RIDGE (1980 pop. 30,293)			
Electric Power (kwh)	21,568	22,443	22,158
Constr. ($)—Res.	496	64	117
—Nonres.	212	0	5,431
Deposits ($) (2 of 2 banks)	70,938	69,928	60,412

[a]Regional figures.
[b]Electric Power consumption figures are not available.
[c]Includes adjustments.

NOTES: Population figures are 1980 census counts.
Construction figures are valuation of new residential and nonresidential construction only.
Deposit figures are total deposits in commercial banks as of last day of month.
n.r.—not reported
*—preliminary data
r—revised data.

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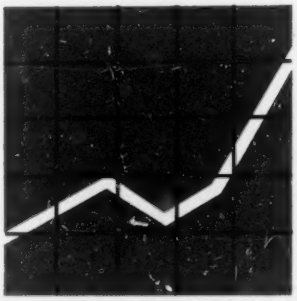

Colorado Business Review

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Volume LVI, Number 2, February 1983

Solar Energy Research Institute

Judith Morison

The Solar Energy Research Institute (SERI) opened its doors in Golden, Colorado in July 1977 as a national center for federally sponsored solar research and development. The Institute was established by Congress in the Solar Energy Research, Development, and Demonstration Act of 1974, which authorized a federal program aimed at developing solar energy as a viable source of the nation's future energy needs.

With a current annual budget of approximately $44 million, and a staff of 560, SERI's mission is to be the nation's primary federal laboratory for solar energy research, development, and testing.

Like the other federal laboratories, SERI is a "GOCO," a government-owned, contractor-operated organization; that contractor being Midwest Research Institute (MRI), an independent, not-for-profit research organization headquartered in Kansas City, Missouri. Dr. Harold Hubbard, who was appointed director of the Solar Energy Research Institute in December 1981, continues as senior vice president of MRI, which he joined in 1970.

FEDERAL ROLE IN R&D

"The beginning of this decade was a turning point for R&D in America. A stagnating economy cut into the tax base that had for a long time funded the federal R&D role. After decades of increased federal funding of science and technology, we are now seeing a new set of rules, whose key terms are 'redefinition' and 'reexamination' of the federal role, and whose stated philosophy is 'private sector expansion in R&D.'" Dr. Hubbard thus summarized the guidelines for the federal role in R&D for representatives of federal labs at a recent conference on technology transfer.

In accordance with these guidelines, SERI'S mission is to perform long-term, high-risk, potentially high-payoff research that industry cannot afford to undertake. This work advances scientific understanding and establishes a sound technological base, enabling the private sector to make well-informed choices among technology options.

"SERI exists for only one purpose: to develop science and technology applicable to the utilization of renewable energy resources and to put that science in front of the private sector so it can be used. Thus, SERI takes its technology transfer role very seriously," said Dr. Hubbard.

The fruits of SERI's research are only realized when they can be translated into products for industry and consumer use. And in the short five and a half years of the Institute's existence, SERI's research has led to breakthroughs in several technologies which are in the process of being adopted by industry.

THE RESEARCH DIVISIONS

SERI's research is grouped into three divisions: Solar Electric Conversion Research, Solar Fuels and Chemicals Research, and Solar Thermal and Materials Research.

Judith Morison is a Public Affairs Officer with SERI. Prior to her five years with the Institute, she was Communications Specialist at the Regional Transportation District.

- The Solar Electric Conversion Research Division is primarily involved in photovoltaics (solar cell) research, which is the largest single program at SERI. The Division is responsible for management of the photovoltaics advanced research and development program and the innovative wind energy systems program.
- The Solar Fuels and Chemicals Research Division applies the chemical and biological sciences along with related engineering disciplines toward development of new concepts for the production of fuels and high-energy chemicals. The Division conducts research and manages contracts in the production and conversion of biomass as well as the direct use of solar energy through photoconversion to chemical potential energy.
- The Solar Thermal and Materials Division is responsible for research in solar thermal processes and materials and other supporting research. Activities in the solar thermal processes area include active, passive, and hybrid heating and cooling systems; solar thermal technology primarily for industrial and utility applications; thermal energy storage; and ocean energy conversion.

In the past year alone SERI announced research advances in all three major research divisions. Several SERI-funded projects advanced to the point where they showed commercial potential, and were turned over to industry for further development.

PHOTOVOLTAICS

Many of these advances occurred in the field of photovoltaics (PV), SERI's top research priority. Forty percent of SERI's budget is devoted to research on these solid-state devices that convert sunlight directly into electricity.

The most widely used and technically developed solar cells are based on a thin slice or wafer of silicon cut from a nearly perfect silicon crystal of high chemical purity. The technical feasibility and reliability of these "single crystal silicon" solar cells have been proved for many years—such PV cells are used extensively in the space program.

But the high cost of present PV systems has generally limited terrestrial applications to small-scale, remote operations. Photovoltaic arrays can be purchased for about $10,000 a kilowatt, about six times the cost per kilowatt of nuclear or coal-fired electric plants. However, there are already about 10,000 residences around the world with photovoltaic cells providing electricity. At SERI, the goal is to perform research with the potential of reducing the cost of solar cells to less than $1,000 a kilowatt.

Even at $10,000 a kilowatt (or $10 a watt), however, photovoltaic sales in the United States last year totaled about $120 million. According to the *Wall Street Journal* (12/30/82), the Worldwatch Institute predicts that the photovoltaics business will be a billion-dollar-a-year industry by the late 1980s and could push close to the $10 billion mark by the end of the century.

Various alternatives to the single crystal silicon cell are being explored. Some researchers are concentrating on producing silicon in a more cost-effective way; others are working to improve performance of innovative solar cell

concepts; still others are seeking new materials or processes to bring the cost down still further.

The past year has seen major advances in solar cell technology–both in in-house research and research performed under subcontract from SERI–and several promising technologies have been turned over to private industry for further development.

The lowest cost potential may be in the area of thin-film solar cells, which offer material conservation, simplified film growth techniques, and use of inexpensive substrates. A thin-film cell of copper indium diselenide being researched at Boeing Aerospace under contract to SERI led to the 1980 announcement of a 9.4% efficiency, at that time the highest efficiency to be attained in cells of this type. Since then, Boeing has consistently made cells exceeding 10% efficiency in the laboratory. In November, Boeing Engineering announced the formation of a joint venture with Reading and Bates of Tulsa, Oklahoma, an oil exploration firm, to develop thin-film solar cell modules for commercial markets. The Seattle-based joint venture, called SOVOLCO, hopes to have a pilot plant in operation by 1985.

"This is the first truly thin-film cell with an efficiency greater than 10% that has proven stable over a long period of time," says Dr. Allen Hermann, Manager of SERI's Polycrystalline Thin-Film Photovoltaic Program. "Further research could lead to higher efficiency and much lower cost than silicon cells, which would allow for rapid expansion of photovoltaics into new applications."

Another significant result of SERI's photovoltaic research program is the Motorola/Shell Oil private venture, SOLAVOLT International, which will commercialize a cheaper ribbon-to-ribbon (RTR) production method developed by Motorola with SERI funding. The RTR process is one of a number of technologies which produce silicon sheets or ribbon directly, i.e., without forming a silicon ingot which is then sliced.

Patent is pending for a SERI-invented method for growing thin, flat crystal sheets of silicon for use in inexpensive solar cells. The technique, called "edge-supported pulling" (ESP), was developed at SERI in 1980 and has now been advanced to a stage where industrial firms were invited to bid on a public solicitation to continue development of the process. Arthur D. Little, Inc. was selected from six bidders and began work under the guidance of SERI researchers last year. In this process, sheets of silicon are drawn between two thin filaments from a molten silicon bath.

SERI also manages an aggressive research program in amorphous silicon. This material can absorb 90% of usable solar energy in a micron thickness, can be produced at lower temperatures, and deposited on a low-cost substrate. Economic studies indicate that amorphous silicon modules could be cost-effective for residential applications at efficiencies of 8%. Last July, RCA, a SERI contractor, announced the demonstration of 10.1% efficiency in an amorphous silicon cell, the highest ever reported.

SERI researchers also have invented an electrorefining process for purifying metallurgical grade silicon, with the potential of greatly lowering the cost of this purification process. The new method is a one-step process that yields 99.9998% pure silicon.

Progress is being made too with "stacked" cell arrays in which each cell uses a different part of the solar spectrum and yields a high overall efficiency. SERI researchers have received a patent on a unique "superlattice" growth technique used in making the cells.

As costs decrease and more efficient methods of manufacturing solar cells are found, the use of PV systems for residential purposes is expected to increase greatly. It is anticipated that eventually homeowners will be able to hook up PV arrays to their homes, then sell back surplus electricity to local utilities. New residential housing appears to be the next major market for solar cells, with the market extending to widespread retrofit and commercial use by the 1990s.

SOLAR FUELS AND CHEMICALS

While electricity accounts for about 28% of the energy used in this country, about 24% of U.S. energy consumed is in the form of transportation fuels. Alcohol fuels can be substituted for petroleum, and alcohol can be made from "biomass" plants produced by sunlight. Cost-effective processes to produce alcohol fuels and high-efficiency systems to use them will make renewable fuels a competitive option.

In 1982, a SERI-invented gasifier was lauded as one of the 200 most significant technological advancements of the year by *Industrial Research & Development* magazine. The oxygen high-pressure gasifier converts biomass–such as wood and agricultural wastes–into synthesis gas for the manufacture of methanol or ammonia. It is the first gasifier designed especially for methanol production from biomass.

The one-ton per day pilot gasifier developed at SERI over the last several years is now ready for industry scale-up to commercial size. According to Dr. Thomas Reed, SERI principal scientist and co-inventor on the project, "One hundred and ten tons per day of agricultural or wood residues could be converted into 55 tons of methanol in completely automated plants." Applications include use in farm co-ops and forest industries, where methanol for transportation, ammonia, and pipeline gas could be made from local wastes.

"With the increased price of oil and gas, solid fuels have become important energy sources," says Reed. "With

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this invention it is now practical to make relatively small processing plants to produce methanol."

Patent rights are held by Dr. Michael Graboski of the Colorado School of Mines, who served as co-inventor on the project, under contract to SERI. Dr. Graboski is currently pursuing plans with industry to build a mid-sized, 60-ton/day plant over the next three years. Eventually, skid-mounted plants twice that size could be mass-produced much the way modular homes are today.

Those commercial plants, Graboski estimates, would sell fuel wholesale for about 85 cents a gallon in today's dollars. Methanol from natural gas now costs about 75 cents a gallon, but that price is expected to go much higher when remaining federal controls on natural gas prices are lifted in 1985.

SERI is not only researching more cost-effective ways to produce solar fuels, but is developing more efficient systems to use them. One of these, in a Chevrolet Citation, converts liquid methanol from the fuel tank to hydrogen gas at the engine and operates at high efficiency. SERI researchers have performed road tests and chassis dynamometer tests to determine fuel economy and exhaust emissions; and are now working on scaling down the system to even smaller size. Automobile manufacturers and energy companies have expressed significant interest in this low-cost approach to alternative fuel for internal combustion vehicles.

Specific technologies developed at SERI will not only lead to new products, but may even foster entire new industries. One such longer-term project includes the production of hydrogen and oil by microalgae. Some species of microalgae accumulate up to 80% of their cell mass as oil, which can be extracted as a basic chemical feed for the manufacture of liquid fuels and other products. A potential oil production rate of one-half to one barrel of oil per acre per day is estimated. To meet total U.S. oil demand using this technology would require more than 18 million acres of algae ponds; and SERI has identified 86 million acres in the southwestern United States that could be suitable.

SOLAR THERMAL

SERI provides the infant solar thermal industry with a center where research is performed and the results are integrated, with the help of industry, into prototype systems leading to new or improved products.

SERI's role can be divided into two specific areas: investigation of new ideas, materials, and advanced concepts for introduction into advanced solar thermal concepts; and evaluation of the performance and durability of materials, prototypes, and systems produced by manufacturers to establish a technology base for future solar thermal systems. This evaluation, when conducted by SERI, makes available to industry the unique laboratory and outdoor test facilities expensive for industry to duplicate.

One such prototype–a steam generating solar industrial process heat (IPH) system–is now being tested at SERI's field test site on South Table Mountain in Golden. The IPH system, consisting of 2,320 square feet of parabolic collectors, was designed by the Foster Wheeler Corporation of Livingston, New Jersey as part of the Department of Energy's Modular Industrial Solar Retrofit (MISR) project. Four other industrially designed and fabricated systems within this project are being evaluated at Sandia Laboratories, Albuquerque, New Mexico.

The MISR project represents one step in a major thrust by DOE to bring line-focus solar thermal technology to the point of readiness for industrial applications. The project emphasizes development of modular systems that generate steam at temperatures up to 600°F. A modular design approach ensures systems that can be widely used in many applications; and simultaneously encourages improved reliability through the use of standardized components and installation procedures.

Reports of test data as well as operational experience with the system will be published and made available to industrial engineers who are considering adding solar process heat systems to their plants.

SERI leads the solar thermal materials research for the Department of Energy. An example of SERI leadership in the area of materials research and development includes stimulating thin glass development by the Corning Glass Company. SERI and Corning Glass worked together to achieve an improved, high transmittance, flexible glass. Major heliostat manufacturers are now using thin glass in their heliostat designs with potentially lower cost.

Although solar energy is most often thought of as providing heat, SERI is investigating a solar cooling technology that uses 40% of the electricity required by conventional air conditioners. The process–called desiccant cooling–turns hot, humid air, into hot, dry air by passing it through a silica gel or other absorber material. It is then passed through a heat exchanger and further cooled.

The Solar Desiccant Cooling Program directs research and development activities toward production of residential desiccant cooling systems able to compete in the marketplace. SERI researchers have tested three prototype systems and developed an innovative design for the dehumidifier wheel. This new "parallel passage" design greatly reduces the pressure drop through the wheel and thus requires far less power to drive the fan. The breakthrough makes possible a system coefficient of performance (COP) about double that of conventional designs. This suggests that solar desiccant cooling systems will be competitive with conventional cooling systems in five to ten years.

Although the system requires electrically driven fans and possibly pumps, the heat for regenerating the desiccant material can be supplied by solar collectors. The same collectors would be used for both heating and cooling the house, making the economics for installing a solar system much more favorable.

CONCLUSION

These examples illustrate the span of technologies addressed by SERI. The Institute's continued pursuit of new opportunities and improvements in solar energy conversion can be expected to result in many such new products for industry, and in economic benefits for society.

"The American public pays for SERI–as the American public pays for all of the federal research labs. SERI's responsibility is to do relevant research that contributes to this country's scientific and technical base, and permits us to use its renewable energy resources; to do research that is pertinent and useful, and to perform it in an expeditious and cost-effective way," said Dr. Hubbard.